# The Optical Terrace: An example of multidisciplinarity in student-led initiatives

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## ABSTRACT

In honor of UNESCO'S First International Day of Light (IDL) in 2018, Université Laval's SPIE Student Chapter set out to design a large-scale outreach initiative that would be both artistic and educational. The goal of this project was to design a new way for people to interact with light through human-scaled experiments outside of traditional channels such as schools, museum or libraries. It was realized that the required skills to fulfill requirements would exceed those of the mostly physics-oriented student chapter.

Between the three consecutive yearly editions of The Optical Terrace, multidisciplinarity was a focus for this student-led initiative. Promoting collaboration between physics, architecture, art, marketing and communication has proven to be a challenge that our team has learned to manage. In this paper, we will explain the solutions we came up with that had the most success in keeping active involvement of our members and to steer the design within our requirements.

**Keywords:** Education and training, Multidisciplinarity, Optics education, Outreach programs, Physics, Visibility

## 1. INTRODUCTION

Every year, Université Laval's joint SPIE and The Optical Society (OSA) student chapter, the Regroupement des étudiants en photonique et optique de Laval (REPOL) has made a point of providing visibility to the field of Optics and Photonics (O&P) for at least 12 years now. Even if this is a fascinating area of physics with a considerable economical impact in a few cities around the world, it remains largely unknown to the general public. This is especially true in Québec City. Despite producing world-class academic research, creating more than 3000 jobs and generating over $400M in total revenues[1,2] most of the citizens remain unaware of the existence of the optics and photonics (O&P) sector. This has real impacts for the development of this industry, since there is a very high employment rate combined with a lack of workers, meaning that companies are actively looking for new employees. During the numerous activities that the student chapter developed to improve the visibility of O&P ,[3,4] it was made very clear that traditional channels like schools, museums or libraries were not an ideal environment to reach people which aren't already or typically interested in science. This is why we decided to try a new approach to our outreach mission.

The 2018 first International Day of Light (IDL) proved to be an excellent opportunity for reaching out to an extended public by the means of a large-scale project. The general idea was to combine science outreach with art in a public open space to stimulate curiosity and interest at a distance regardless of the people's background. It was quickly realized that the skills needed to fulfill the project's requirements would exceed those of the mostly physics-oriented student chapter, and that involving students from other background would be necessary. Thus, we recruited two undergraduate architecture students to bring a more diverse expertise to the team. Architecture seemed a natural choice since multiple student led initiative similar to what we had in mind originate from the

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(a) Render top view (b) Built and installed

Figure 1: Optical Terrace year 1 structure

École d'architecture de l'Université Laval (ARC), which houses both graduate and undergraduate programs. The project then started to take form, leading to the realization of the Optical Terrace (OT), which is described in another proceeding [5] and where the challenges of multidisciplinary in student-led projects was briefly discussed.

This proceeding will show the steps the student chapter has taken in order to ease the project management of such teams. We will expose the details of our project structure, the different steps and obstacles we had to tackle leading to both edition of the terrace, and finally our conclusions and lessons learnt on these types of project. Through this proceeding, we hope to inspire other students chapter to design these kind of projects even if the management of diverse teams can seem challenging.

## 2. PROJECT DESCRIPTION

### 2.1 Requirements and design

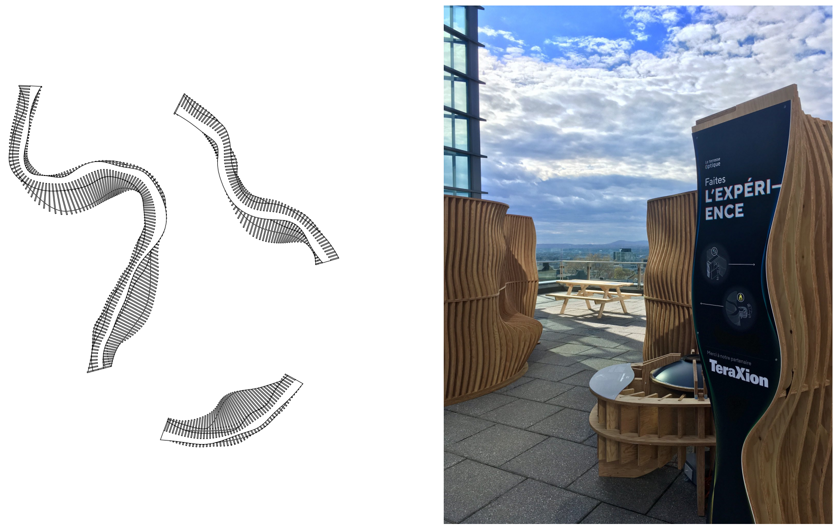
Before forming a larger multidisciplinary team, some guiding principles were formulated in the form of a high-level requirement list that the project had to solve in order to be successful and useful for the O&P community in Québec city. Here is a brief summary of those guiding principles:

1. The Optical Terrace will be a way for the public to learn about the role of O&P in their everyday lives;
2. The Optical Terrace will be an urban public space for the general public to enjoy and visit;
3. The Optical Terrace will house interactive human-scaled experiments for the public;
4. The experiments will be kept simple enough so that a child of approximately 12 years old can grasp a coarse understanding of the physical phenomena at play.

### 2.2 Structure

#### 2.2.1 Year 1

The design of the first Optical Terrace is shown in figure 1. The overall design of the structure was meant to be simple yet intriguing by integrating interactive experiments at the human scale so that a visitor of the terrace would be a *user* and not only an *observer*. Three large boxes, also referred to as *stations*, contained the experiments and were oriented in such a way that they encouraged wandering between the different stations of the structure. A large platform, the terrace itself, connected these three spaces, and a large pergola acted as a common roof, giving the impression that the three experiments were parts of a coherent and unified space.




(a) Plan top view (b) Built and installed

Figure 2: Optical Terrace year 1 structure

(a) Decentered view (b) Head-on view

Figure 3: Perspective experiment

### 2.2.2 Year 2

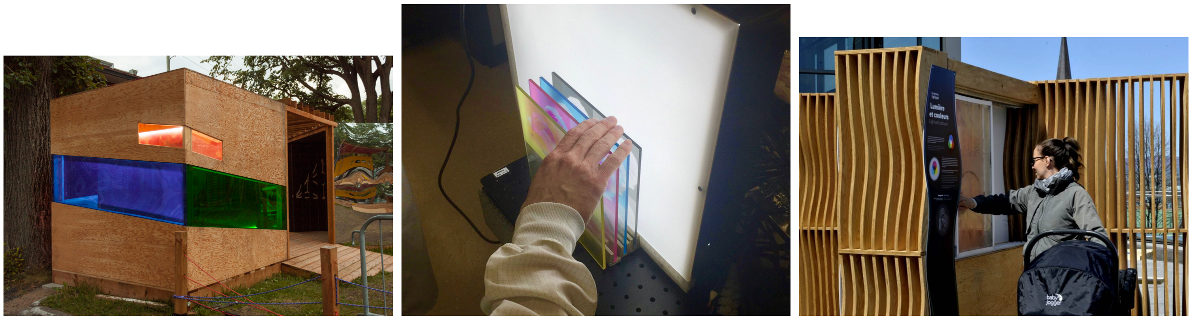
Following some logistics problems with the first structure (covered in section 3.2), a major design change was necessary for the second edition, as can be seen in figure 2. This time, the large scale experiments were integrated seamlessly with the design instead of relying on a naive solution where each section of the terrace is a different experiment.

For the new design, we thought that light should be at the center of the creative process. Given that light sometimes acts as a particle, and other times as a wave, curved walls with undulating surfaces flowing smoothly along the structure were made out of a series of solid wood boards to reflect this idea in the architectural design. These long walls then created spaces for experiments or resting areas.

## 2.3 Experiments

One of the main requirement of the OT is to provide large-scale experiments to the general public as a mean to teach about optics and its role in our everyday life. For this reason, the design of experiments which can be blown to a large scale and robust enough to last an entire summer is one of the most important aspect of the project. Moreover, since we require that a child as young as 12 years old be able to learn from the experiments of the OT, it is very important to make them interesting and accessible.

Each edition had a minimum of three different experiment we wanted the users to interact with. Here, we will describe two of them, from the initial idea to the final design and integration inside the structure.



(a) Year 1 light subtraction (b) Year 2 light subtraction in lab (c) Year 2 light integrated[6]

Figure 4: Perspective experiment

### 2.3.1 Perspective

The perspective experiment can be seen in Figure 3, as integrated in the year 1 structure. The effect relies on the anamorphic projection of geometrical shapes on a wall. Using baffles, we were able to paint (with the help of a projector) two different shapes on the same wall depending on the orientation of the observer. We instructed the viewer to move around The Optical Terrace to find the exact position where the deformation is minimal, allowing them to see the original image.

Even if the effect is simple and easy to understand, it was difficult to communicate to people how to explore the space and how their angle of view on the object affected its shape. For this reason, we decided not to include it in the second edition of the terrace.

### 2.3.2 Light subtraction

Explaining colors to the general public is something that we try to do each year since the decomposition of color is at the heart of many technologies in our daily lives.

The first year, the experiment was based on spectroscopy, the science of extracting information from the chromatic components of light. In order to show this in a simple way at a human scale, we decided to use colored filters (in our case, commercial colored acrylic panels) to view a different image depending on the filter that is placed in front of a specially designed composite image (figure 4. This composite image was made by superposing three grayscale images which were colored according to the different filters that we chose so that only one of these images could be seen through the filter. People were instructed to compare the three images seen through the filters on the faces of the cube to the complete one inside the cube. Clear windows were placed into the structure near the colored windows so that visitors could see both the composite image and the filtered image at the same time. However, we later realised that people were also confused by having to move around to see all images. For this reason, we decided to try something radically different for the second year.

Instead of relying on the spectral decomposition of a composite image, we chose to let people interact with the multiple color layers of a color picture. This optical effect is very similar to a standard four color printing process which is used by pretty much every home printer. This time, a painting from a local artist was split in cyan, magenta yellow and black layers (figure 4) and printed on large acrylic panels with a low opacity. People could recompose the image by sliding color layers in and out and seeing the effect of each color on the completed image.

## 3. PROJECT MANAGEMENT

As alluded earlier, one of the main challenges with such a large-scale project is the management of a diverse team. Both technical and logistical problems will arise in the project and the whole team must be able to get support to resolve them in a way that will not be too costly, both in time and money, and according to the requirements. This section will present solutions we used in this project that can be applied to small organization (around 10 members) working on a larger scale short-term project (6-8 months).

### 3.1 Organizational structure

The REPOL, our joint SPIE and OSA student chapter at Université Laval, already had some valuable experience in organizing public outreach activities[3,4] which shared some similarities with the concept of The Optical Terrace. Based on our previous experience, forming a dedicated committee for the project within the student chapter, which would recruit students from outside the chapter's executive committee, was the best way to operate for the first year. Since we didn't know if the project would be renewed the second year, this reduced the administrative overhead that would incur with creating a new organization.

In all our previous outreach projects, all organizing members were members of the REPOL, meaning that they all studied in optics and photonics and shared similar academic backgrounds. However, the need for multi-disciplinary within this project was evident from the start and required students with a training in architecture to design the structure itself. Two students from ARC would be responsible for this essential aspect of the project and were the first addition from outside the REPOL to be integrated in one of our outreach initiative.

#### 3.1.1 Year 1

For the first year, we created small teams that would each work on a specific section of the project:

1. Project management (3 members)
2. Architectural design (2 members)
3. Experiment design (4 members)
4. Logistics (2 members)

Since the project relied on the mother organization, the REPOL, for administrative purposes, their treasurer monitored the project's expenses and its funding. This proved to be a mistake which would be fixed in year two because the high volume of transaction proved to be too much for the student chapter to handle on their own.

The role of the management team was to lead and support the project by doing most of the administrative work, such as booking public spaces to occupy, getting the structure insured in case of vandalism or civil liability, and finding funding from academic and private sources. Above all, their main task was overseeing the work and progress of the different teams and making sure that the project's timeline, budget, design requirements and mission were all respected over the course of its development.

The experiment design team oversaw the most crucial part of The Optical Terrace, i.e., the outreach experiments. They made sure that the human-scaled interactive stations with different optical phenomena were fun, understandable and easy to use for visitors of all ages. They were also responsible for finding all special materials and overseeing the integration with the architectural design team to ensure a seamless transition between learning material and architectural design.

The logistics team was formed during the last phase of the project once the design of the structure was completed. This team was to help in building the structure itself, integrating the experiments within the platform and helped organizing the terrace's opening ceremony.

#### 3.1.2 Year 2

For the second edition, we decided to expand the team in order to fix a few problems encountered the first year. As we explained in section 2.3, we noticed some confusion about how to interact with the large scale experiments integrated in the OT. That meant that adding people with an education background would help to streamline experiments and offer a better experience for the public. We also realized that we needed help to promote the OT so people would travel to us instead of relying on chance. Here is the new organisational structure:

1. Project management (3 members)
2. Communications (1 member)

(a) Construction (b) Moving

Figure 5: Year one logistics

3. Education and interaction (2 members)
4. Graphic design (1 member)
5. Architectural design (2 members)
6. Experiment design (4 members)
7. Logistics (2 members)

These added team were mostly acting as counsel to the core team and didn't lead design projects. Also, for this edition, the comity was mostly independent from REPOL since this caused some problem the first time around, which meant that the management team had to handle finances and more administrative duties. These addition meant that even more people with different background were working on the same project which meant that efficient communication between team members became a challenge.

## 3.2 Logistics

### 3.2.1 Year 1

Since the development of the first edition was done on a tight schedule (during a span of 3 months), the experiments and the structure were designed in parallel, nearly at the same time. This meant that the main objective of the OT were prioritized over practicality. Figure 5 illustrate some of the logistics problem that were encountered during the construction of the terrace. Firstly, due to time constraints, it was easier and less costly to build the terrace as a permanent structure instead of a modular one that could easily be disassembled for storing or moving purposes. This meant that moving the three 8ft cubes and 16ft platform had to be done with an expensive platform truck and a dedicated house moving company. Extensive reassembling had to be done after moving in order to securely reattach the cubes to the main platform.

This is an example of a problem that could easily have been avoided with proper planning and time management. Since no high level requirements were firmly in place for moving and packaging the whole system, the design was steered in a direction which helped with experiments integration and ease of construction.

(a) Construction
Figure 6: Year two logistics

#### 3.2.2 Year 2

For the second edition, the team came with the experience of the first year when it came to the design and the collaboration between architecture and scientific outreach. Early on, explicit requirements were put in place to allow the terrace to be built and moved more easily. This meant that the decision to design a new OT instead of reusing the one year-old terrace had to be made at the beginning of the year.

The newly designed optical terrace (figure 2) could be split up in small $7\,5 \times 3$ft sections which could be moved using a standard moving truck. Figure 6 shows the simple assembly that had to be done on site: securing these wall sections using eccentric screws and hiding the joint using additional perpendicular wall planks.

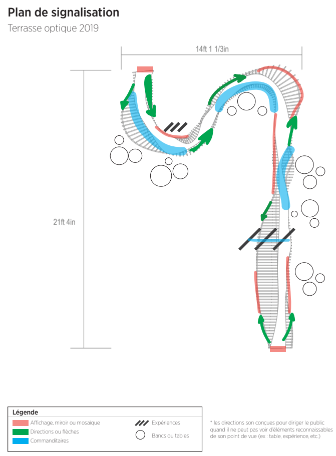
### 3.3 Challenges of multidisciplinarity

Over the two years course of designing the OT, our student chapter has learned a lot about management of small teams composed of individuals having very diverse backgrounds.

As it could be seen in section 3.2, this came at the expense of some mistakes that were the result of poor planning and miscommunication within the team.

For the second edition, we decided to expand the team to include even more different disciplines in order to find solutions to the weaker parts of our design. This meant that the challenges encountered the first year needed to be addressed directly in order to reduce the risk of making the same mistakes over again. The following is a non-exhaustive list of the most important challenges:

- Synchronising schedules
- Keeping meeting short and efficient
- Efficient communication between sub-teams
- Motivating the team to work on the project
- Generating an explicit requirement list
- Budgeting for logistics and potential mistakes




(a) Year 2 user interaction map

(b) Year 2 large scale mirascope

Figure 7: Collaboration examples

These challenges are in no way limited to diverse teams, but are amplified in teams featuring a lot of multidisciplinarity. For example, communication between sub-teams can be difficult because they mostly don't speak with the same vocabulary or have the same problem-solving approach. Here is a short list of simple solutions that helped us with the problems we were facing the first time around:

- Respecting each other area of expertise
- Keep a close eye at high-level requirement when negociating a common ground
- Prioritize workshop to solve problems instead of brainstorming in a meeting
- Team building is important, even more so when the team is diverse
- Take a lot of meeting notes and pictures
- Take every opportunity to collaborate on a problem instead of solving it in your own sub-team

These simple steps helped us solve most of the problem which degraded user experience the first time around. A great example of this is the confusion some people felt when navigating the OT. The addition of user interaction specialist helped the experiments team as well as the architecture team to communicate more efficiently and to design the structure around the user experience. Figure 7a is an example of a design map that was used in order to study how a person would interact with the structure and where experiments should be placed.

A second example of this is the large scale mirascope that was custom built by the experiment team using large parabolic mirrors. The design of the mount (Figure 7b) which was in line with the design language of the OT was a real challenge that involved most of the team. It's placement inside the space was also a challenger which involved the interaction map as well as a signalisation map to ensure that people would find the experiment and would correctly interact with it.

### 3.4 Conclusion

We believe that the main goal of the OT, which was to share the importance of different light phenomena in our everyday life, was successfully achieved for both editions.

However, we also faced several challenges in relation to user experience and logistics the first year, which we fixed during year two by adding some key members to the team with more specialized skills in these areas.

In conclusion, we are certain that the advantages of multidisciplinarity far outweights its downsides, which are mainly due to management and communication within the team. It would be impossible for student-led initiatives like the OT to be successful if it wasn't for the involvement of many students having diverse academic backgrounds. We also firmly believe that being part of such teams is also beneficial to the members since the problem solving solutions that come up are mostly applicable to scientific research were multidisciplinarity is more and more present.

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